ARM ASSEMBLY FOR EXCAVATION APPARATUS AND METHOD OF USING SAME

Cross-Reference to Related Applications

This application claims benefit of the filing date of U.S. provisional application no. 60/391,062 filed June 24, 2002 and U.S. provisional application no. 60/411,181 filed September 16, 2002, and both of said applications are hereby expressly incorporated by reference herein.

Background of the Invention

The present invention relates generally to construction, excavation and/or other heavy machinery such as excavators, backhoes and the like that include an arm assembly comprising an arm or "stick" and a control link, each or which is adapted for pivotable connection to an associated attachment such as a bucket or other implement for performing work, and all such machines are referred to herein as "excavation apparatus" of "excavators." The control link is operably coupled to a hydraulic cylinder or other actuator, and the position of the control link as controlled by the actuator controls the angular position of the attachment relative to the arm, i.e., extension and retraction of the control link results in curling and roll-back of the attachment, respectively.

To improve the utility and versatility of such excavation apparatus, it is most desirable that various implements be conveniently and reliably coupled to the arm. This, then, allows a single excavation apparatus to be employed with any one of a wide variety of attachments as desired. However, given the size and weight of the attachments, and the close tolerances of all connection points, changing of attachments at the end of the arm of an excavator has been found to be time-consuming, difficult and inconvenient.

In a most basic arrangement, the attachments are manually pinned to the excavator arm and any associated fluid cylinders. Such operation necessarily

requires manual removal and replacement of multiple pins to achieve the desired engagement.

More recently, quick-coupler devices have been developed and have enjoyed widespread commercial success. One suitable coupling is commercially available from JRB Company, Inc., Akron, Ohio under the trademark SmartLoc™. Such quick-couplers are pivotally pinned to the distal end of the arm and control link in the same manner as an attachment. Once a quick-coupler is operatively pinned in position, first and second recesses thereof are adapted for selective connection to first and second pins of any of a wide variety of associated attachments in a convenient and secure manner without removal of the first and second pins.

Although these quick-couplers are highly effective and convenient, they add weight to the excavator arm and also elongate the arm, the combination of which can lead to a decrease in excavator performance in certain circumstances. The additional weight of the quick coupling can decrease the lifting capacity of the excavator. The outward movement of the attachment can also reduce lifting capacity and can change the performance characteristics of the attachment.

As such, a need has been identified for an attachment quick-coupling apparatus that provides the advantages of conventional quick-coupler apparatus without many of the drawbacks associated with same.

Summary of the Invention

In accordance with a first aspect of the present invention, an arm assembly for an excavator includes an arm comprising a first hook including a first open mouth. The arm further includes a first pin capturing system that selectively obstructs the first open mouth. A link is movable relative to said arm and comprises a second hook including a second open mouth. The second open mouth is oriented toward the arm, and the link further comprises a second pin capturing system that selectively obstructs the second open mouth.

In accordance with another aspect of the present invention, an arm assembly for a machine includes an arm comprising a first hook including a first open mouth. The arm further comprises a first pin capturing system that selectively captures a first associated pin in the first hook. A link is movably connected to the arm and comprises a second hook that includes a second open mouth. The second open mouth is oriented toward the arm and the link further comprises a second pin capturing system that selectively captures a second associated pin in the second hook.

In accordance with a further aspect of the invention, an apparatus comprises an arm assembly and an attachment operably connected to the arm assembly. The arm assembly comprises: (i) an arm comprising a first hook including a first open mouth and further comprising a first pin capturing member that selectively captures a first associated pin in the first hook; and, (ii) a link movably connected to the arm and comprising a second hook that includes a second open mouth, and further comprising a second pin capturing member that selectively captures a second associated pin in said second hook; The attachment comprises: first and second attachment pin assemblies. The first attachment pin assembly is non-rotatably captured in the first hook by the first pin capturing member, and the second attachment pin assembly is non-rotatably captured in the second hook by the second pin capturing member.

In accordance with another aspect of the invention, an attachment comprises a body and first and second spaced-apart ribs connected to the body. First and second spaced-apart pins extend between the first and second ribs. First and second sleeves are rotatably positioned on the first and second pins.

In accordance with a further aspect of the present invention, a sleeve for connection to an attachment pin includes a tubular portion comprising a cylindrical outer surface and defining a through-bore adapted for receipt of an attachment pin. First and second spacers are connected to opposite first and second ends of the tubular portion. The first and second spacers define

respective first and second bearing surfaces that face outwardly away from each other. First and second seals are connected to said first and second spacers and overhanging the first and second bearing surfaces, respectively.

In accordance with a still further aspect of the present invention, a method of coupling an attachment to an arm assembly comprises moving a first open hook into engagement with a first pin of an attachment. The first open hook located at an end of an arm. A first pin capturing system is engaged to capture the first pin non-rotatably in the first open hook. The arm is moved to lift the attachment so that the attachment hangs freely from the arm by way of the first pin. The arm is pivoted and the link is moved relative to the arm so that a second open hook located at an end of the link moves into engagement with a second pin of the attachment. A second pin capturing system is engaged to capture the second pin non-rotatably in the second open hook.

Brief Description of the Drawings

The invention comprises various components and arrangements of components, and comprises various steps and arrangements of steps, preferred embodiments of which are disclosed herein with reference to the accompanying drawings that form a part hereof and wherein:

FIGURE 1A is a right side elevational view of an arm assembly formed in accordance with the present invention and including an arm and a control link both formed in accordance with the present invention;

FIGURE 1B is a left side elevational view of the arm assembly shown in FIGURE 1A;

FIGURE 1C illustrates an attachment to be operatively coupled to the arm assembly of FIGURES 1A and 1B to perform work, wherein the attachment includes pin sleeves in accordance with the present invention;

FIGURES 2A and 2B are side elevational views that illustrate the nose portion of an arm formed in accordance with the present invention, in an unlocked and locked condition, respectively;

FIGURE 3A is a side elevational view of a pin capture member that forms a part of the nose portion shown in FIGS. 2A and 2B;

FIGURE 3B is a view taken along line B-B of FIG. 3A;

FIGURE 3C illustrates a mechanical lock pin formed in accordance with the present invention;

FIGURE 4A is an isometric view of the control link portion of the arm assembly shown in FIGS. 1A and 1B;

FIGURES 4B and 4C are side elevational views of the control link shown in FIG. 4A in an unlocked and locked state, respectively;

FIGURES 5A and 5B are top plan and side elevational views of a frame portion of the control link shown in FIGS. 4A - 4C;

FIGURES 6A and 6B are top plan and side elevational views of a pin capture member that forms a part of the control link shown in FIGS. 4A - 4C;

FIGURES 7A - 7C diagrammatically illustrate an attachment coupling/decoupling method in accordance with the present invention;

FIGURES 7D and 7E illustrate an arm assembly formed in accordance with the present invention and an associated attachment operably coupled thereto in first and second operative positions, respectively;

FIGURE 8 is an isometric view of a pin sleeve formed in accordance with the present invention that is usable with the arm assembly of FIGS 1A and 1B;

FIG. 9 is a view taken along line 9-9 of FIG. 1C and showing the pin sleeve of FIG. 8 in an operative state;

FIG. 10A and 10B are side elevational views of an alternative control link formed in accordance with the present invention.

Detailed Description of Preferred Embodiments

A preferred embodiment of the present invention is illustrated in the accompanying drawings. Those of ordinary skill in the art will recognize that the present invention and the components thereof, unless otherwise noted herein, are preferably constructed from suitable metals such as various high-strength steels and alloys. Also, in the drawings, some hidden components are shown in broken lines while others are shown in solid lines for clarity and ease of understanding the development.

Referring now to FIGURES 1A and 1B, an arm assembly for an excavation apparatus such as an excavator or backhoe of the like is illustrated generally at **A**. The arm assembly **A** comprises, among other features, an arm or dipper-stick **10**, a control link **12**, and an attachment control cylinder **14**. The arm **10** includes a first end **20** and an opposite second end **22**. The first end **20** includes or defines first and second mounting bores **24,26** to be secured by a pin-on connection to a boom (not shown) and an arm control cylinder (not shown), respectively. The second end **22** of the arm **10** comprises a nose **28** formed in accordance with the present invention as described below.

The attachment control cylinder **14** includes a first end **16** pivotally secured to the arm **10** by a pin-on connection and includes a selectively-extensible rod **18** pivotally secured to the attachment control link **12** by a pin-on connection. First and second guide or "bone" links **30a,30b** are located on opposite lateral sides of the arm **10** and are pivotally secured at their opposite ends to the attachment control link **12** and the arm **10**. The rod **18** of the cylinder **14** is selectively extensible and retractable linearly to effect movement of the attachment control link **12** relative to the nose **28** of the arm **10** (see FIGURES 7D,7E).

FIGURE 1C illustrates an associated attachment **AT** to be operatively secured to the arm assembly **A**. The attachment **AT** (shown herein as a bucket for moving earth or the like) comprises a body **B** for performing work and first and

second parallel (meaning exactly or substantially parallel) spaced-apart pin assemblies **PA1,PA2** that extend between first and second ribs **R1,R2** (see also FIG. 9) that are connected to the body **B.** FIGURE 9 shows the pin assembly **PA2** is detail and the pin assembly **PA1** is correspondingly constructed as will be apparent to those of ordinary skill in the art upon reading this specification. As shown in FIG. 9, the pin assembly **PA2** comprises a conventional attachment pin **P2** and a sleeve **PS** that coaxially surrounds same. Although not shown in FIG. 9, the pin assembly **PA1** comprises a conventional attachment pin **P1** and a sleeve **PS** that coaxially surrounds same. The pin assemblies **PA1,PA2** are described in further detail below. As used herein, the term "pin" is intended to refer to a conventional pin and/or a pin assembly **PA1,PA2** as described herein.

With reference also to FIGS. 2A and 2B, the nose **28** of arm **10** defines or otherwise includes a first open pin-receiving hook or recess **H1** adapted to receive the attachment pin assembly **PA1** with a close fit. The hook **H1** includes a mouth **42** that opens in a first direction through an inner side **S1** of the arm **10** that is oriented inward toward the excavation machine and/or downward toward the ground when the arm assembly **A** is in use.

Referring also to FIGS. 4A-4C, the control link **12** defines or otherwise includes a second open pin-receiving hook or recess **H2** adapted to receive the attachment pin assembly **PA2** with a close fit. The hook **H2** includes a mouth **142** that opens through an inner side **S2** of the link **12** that is oriented toward the arm **10**.

The nose **28** of the arm **10** comprises a first pin-capturing system **C1** (FIGS. 2A, 2B) for selective capturing the first pin assembly **PA1** in the first hook **H1.** The attachment control link **12** comprises a second pin-capturing system **C2** (FIGS. 4A-4C) for selective capturing the second pin assembly **PA2** in the second hook **H2**. When the pin assemblies **PA1,PA2** are captured in the respective hooks **H1,H2**, the bucket or other associated attachment **AT** is said to be operatively connected or coupled to the arm assembly **A**, and, in this

operative state, the rod **18** of the attachment control cylinder **14** is selectively extended and retracted to pivot the attachment **AT** relative to the arm **10** between a first operative position (often referred to as a "dump" or "roll-back" position) as shown in FIG. 7D, and a second operative position (often referred to as a "full-curl" position) as shown in FIG. 7E.

With specific reference now to FIGURES 2A and 2B, the first pin capturing system **C1** of the nose **28** comprises a first pin capture member **40** that is movably connected to a frame **28f** of the nose **28** and adapted for movement between a first or "unlock" position (FIG. 2A) and a second or "lock" position (FIG. 2B). In the first position, the pin capture member **40** is retracted relative to the hook **H1** and, more particularly, relative to the open mouth **42** of the hook **H1** so that the mouth **42** is unobstructed by the pin capture member **40**. The term "unobstructed" is intended to define a condition where the pin capture member **40** is positioned so that it does not prevent movement of the first associated attachment pin assembly **PA1** into and out of the first hook **H1** via mouth **42**. Thus, when the pin capture member **40** is in its first position, the associated attachment pin assembly **PA1** is freely insertable in and removable from the hook **H1** via mouth **42**. Depending upon the dimensions and conformation of the hook **H1** and mouth **42**, the first pin capture member **40** can be completely retracted from the mouth **42** as is preferred or it can partially extend into the mouth **42** even when it is located in the first operative "retracted" position.

FIGURE 2B shows the pin capture member **40** moved to its second operative or "extended" position as where it captures the pin assembly **PA1** in the hook **H1**. In the extended position, the pin capture member at least partially blocks the open mouth **42** of the hook **H1** to prevent the pin assembly **PA1** from exiting the hook **H1** through the mouth **42**. In a most preferred embodiment, as illustrated, the first pin capture member **40** completely blocks the open mouth **42** of the hook **H1** when moved to its second operative position and also closely engages the pin assembly **PA1** to thereby capture the pin assembly **PA1** in the

hook **H1**. The pin capture member **40** preferably includes a C-shaped pin retainer **44** defining a partially-cylindrical recess **46** that closely receives and partially surrounds the pin assembly **PA1** when the pin capturing member **40** is fully extended in its second operative position. The recess **46** and a partially cylindrical inner surface **H1a** of the hook **H1** cooperate to encircle at least a majority (i.e., encircle more than 180 and most preferably at least 270 degrees of) the pin assembly **PA1** when the pin capturing member **40** is extended. Furthermore, the tip **30** of the nose **28** defines a slot **32** that opens into the hook **H1** and also outwardly through the tip **30** so that the slot **32** is open at its opposite ends. The C-shaped pin retainer portion **44** of the pin capture member **40** includes first and second tips **48a,48b**, and the tip **48b** is preferably received in the open slot **32** when the pin capture member **40** is extended as shown in FIGURE 2B. The open slot **32** is self-cleaning in that the tip **48b** urges dirt and debris out of the open slot **32** as it moves into the slot **32**. When the pin capture member **40** is extended, engagement of the tip **48b** in the slot **32** adds strength to the pin capturing system **C1** in that forces exerted by the pin assembly **PA1** on the pin capture member **40** will be partially transmitted to the tip **30** of the nose **28**.

The first pin capture member **40** is shown by itself in FIGURES 3A and 3B. It is noted that the tip **48b** is beveled or chamfered so that, when the member **40** is extended, the tip **48b** acts as a wedge to urge the pin assembly **PA1** further into the hook **H1** if the pin is not already fully seated in the hook. As noted, when the member **40** is fully extended, the pin retainer **44** (in particular the portion thereof defining the recess **46**) also engages the pin assembly **PA1** and urges same fully into the hook **H1** so that the pin assembly **PA1** contacts the hook inner surface **H1a**.

It is most preferred that the pin capturing member **40** be slidably movable to and between its first and second operative positions by means of an actuator such as hydraulic or other fluid cylinder **L1** or another suitable actuator such as a

hydraulic screw actuator or the like that is operably connected between an anchor point and the pin capturing member **40**. In the illustrated embodiment, a cross-pin **CP1** extends laterally between and is secured in aligned apertures in nose **28** and the cylinder **L1** is connected thereto. Manual movement of the pin capture member **40** is also contemplated (by disconnecting it from the cylinder **L1**) and deemed to be within the scope of the present invention. In the illustrated embodiment, the hydraulic cylinder **L1** includes a rod **R1** that connects to a aperture, yoke or other mounting location **50** on the member **40**. The rod **R1** extends and retracts linearly (compare FIGS. 2A and 2B) to move the first pin capture member **40** connected thereto correspondingly.

The first pin capture member **40** further comprises a stop portion **52** including or defining a stop surface **54**. The arm assembly **A** preferably comprises a stop-pin **SP** (see also FIGURE 3C), and first and second stop-pin-receiving locations **60a,60b** are defined by the nose **28**. The first location **60a**, where the pin is shown in FIGS 2A and 2B, is merely an inoperative pin-storage position. When the pin capture member **40** is moved fully to its second operative (fully extended) position as shown in FIG. 2B, the stop surface **54** is located adjacent the location **60b** so that when the stop-pin **SP** is inserted into the second pin-receiving location **60b**, the stop-pin **SP** engages the stop surface **54** and prevents movement of the pin capture member **40** from the second operative position back to the first operative position, even under force of the actuator **L1**. In the event the cylinder **L1** is rendered inoperable, the pin capture member **40** can be moved manually to the extended position and the stop pin **SP** can be used as described to hold the pin capture member **40** in its extended position during use of the arm assembly **A**. The stop-pin **SP** (FIG. 3B) includes a cross-bore **SP-B** that receives a ring, pin or other member that prevents unintended movement of the stop-pin out of either pin-receiving location **60a,60b**. The stop-pin **SP** is tapered at its insertion end to facilitate its insertion.

The nose **28** of arm **10** preferably includes or defines a lift eye **LE** integrated into its frame **28f**. This lift eye **LE** provides an attachment point for a chain or the like as used for lifting articles or other uses.

As noted, an arm assembly **A** formed in accordance with the present invention comprises both the arm **10** (including nose **28**) and the control link **12**. With specific reference now to FIGURES 4B and 4C, the second pin capturing system **C2** of the control link **12** comprises a second pin capture member **140** that is movably connected to a frame **12f** of the link **12** and adapted for movement between a first operative "unlock" position (FIGS. 4A,4B) and a second operative "lock" position (FIG. 4C). In the first operative position, the pin capture member **140** is retracted relative to the hook **H2** and, more particularly, the open mouth **142** of the hook **H2** so that the mouth **142** is unobstructed by the pin capture member **140**. The term "unobstructed" is intended to define a condition where the pin capture member **140** is positioned so that it does not prevent movement of the second associated attachment pin assembly **PA2** into and out of the second hook **H2** via mouth **142**. Thus, when the pin capture member **140** is in its first operative or "unlock" position, the pin assembly **PA2** is freely insertable in and removable from the second hook **H2** via second mouth **142**.

FIGURE 4C shows the second pin capture member **140** in its second operative "lock" position as where it captures the second pin assembly **PA2** in the second hook **H2**. In this second operative position, the pin capture member **140** at least partially blocks the open mouth **142** of the hook **H2** to prevent the pin assembly **PA2** from exiting the hook **H2** through the mouth **142**.

In a most preferred embodiment as illustrated, the pin capture member **140** completely blocks the open mouth **142** of the hook **H2** when it is moved to its second operative position and also closely engages the pin assembly **PA2** to thereby capture same in the hook **H2**. As shown, the pin capture member **140** (shown separately in FIGS. 6A,6B) preferably includes a pin retainer **144** defining

a curved, preferably partially-cylindrical recess **146** that closely engages the pin assembly **PA2** when the pin capturing member **140** is fully extended. The recess **146** and a partially cylindrical inner surface **H2a** of the hook **H2** cooperate to encircle at least a majority of (i.e., encircle more than 180 degrees and most preferably at least 250 degrees of) the pin assembly **PA2** when the pin capturing member **140** is extended. Furthermore, as also shown, a tip **130** of the link **12** defines a slot **132** that opens into the hook **H2** and also outwardly through the tip **130** so that the slot **132** is open at its opposite ends. The pin retainer portion **144** of the pin capture member **140** includes a tongue **148**, and a tip portion of the tongue is received in the open slot **132** when the pin capture member **140** is extended as shown in FIGURE 4**C**. The open slot **132** is self-cleaning in that the tongue **148** moves dirt and debris out of the open slot **132** as it moves into the slot **132**. When the pin capture member **140** is extended, engagement of the tongue **148** in the slot **132** adds strength to the pin capturing system **C1** in that forces exerted by the pin assembly **PA2** on the pin capture member **140** will be partially transmitted to the tip **130** of the link **12**. It is noted that the tongue **148** is beveled or chamfered so that, when the member **140** is extended, the tongue **148** acts as a wedge to urge the pin assembly **PA2** further into the hook **H2** if the pin assembly is not already fully seated in the hook. As noted, when the member **140** is fully extended, the pin retainer **144** (in particular the portion thereof defining the recess **146**) also engages the pin assembly **PA2** and acts as a ramp to urge the pin assembly fully into the hook **H2** so that the pin assembly makes hard contact with the inner surface **H2a**.

It is most preferred that the pin capturing member **140** be slidably movable to and between its retracted and extended position by means of a hydraulic or other fluid cylinder **L2** or other actuator such as a hydraulic screw actuator operably connected between the link frame **12f** and the pin capturing member/retainer **140**. Manual movement of the pin capture member **140** is also contemplated and deemed to be within the scope of the present invention. As

shown, the cylinder **L2** includes a rod **R2** that connects to a aperture, yoke or other location **150** on the member **140**. The rod **R2** extends and retracts linearly (compare FIGS. 4A and 4C).

The pin capture member **140** further comprises a stop portion **152** including or defining a stop surface **154**. Like the arm **10**, the link **12** preferably also comprises a stop-pin **SP** as shown separately in FIGURE 3B, and first and second stop-pin-receiving locations **160a,160b** are defined by the link frame **12f**. The first location **160a**, where the pin is located in FIGS 4A-4C, is merely an inoperative pin storage position. However, when the pin capture member **140** is moved fully to its second operative position as shown in FIG. 4C, the stop surface **154** thereof is located adjacent the pin-receiving location **160b** so that when the stop-pin **SP** is inserted into the location **160b**, the stop-pin **SP** engages the stop surface **154** and prevents movement of the pin capture member **140** from its second operative position to its first operative position. In the event the cylinder **L2** is rendered inoperable, the pin capture member **140** can be moved manually to its extended position and the stop pin **SP** can be used in the described manner to hold the pin capture member **140** in its extended position during use of the arm assembly **A**. As noted above, the stop-pin **SP** (FIG. 3B) includes a cross-bore **SP-B** that receives a ring, pin or other member that prevents unintended movement of the stop-pin out of either location **160a,160b**. The stop portion **152** and stop surface **154** of pin capture member **140** are preferably defined as part of a support rib **162** that extends substantially the length of the pin capture member **140** to add strength thereto.

Referring now particularly to FIGURES 5A and 5B, the link frame **12f** comprises first and second interconnected but spaced-apart parallel or substantially parallel ribs **200a,200b** defining therebetween a space **202** in which the pin capturing system **C2** is held. The frame **12f** includes a first axial end **E1** and a second axial end **E2**. The ribs **200a,200b** define a first pair of aligned bores **210a,210b** that receive a cross-pin **CP2** (see also FIGS. 4A-4C) to which

the cylinder **L2** is connected. The ribs **200a,200b** further define a second pair of aligned bores **212a,212b** that serve as a pin-on connection point for the guide links **30** and also the rod **18** of the attachment control cylinder **14**. The bores **212a,212b** define a central axis **X1** (FIG. 5B) about which the guide links **30** and rod **18** pivot (the opposite ends of the guide links are secured to the nose **28** of the arm **10** by a pin-on connection to a bore (or a pair of aligned bores) **214** numbered in FIGS. 2A,2B). The hook **H2** includes an inner partially-cylindrical surface **H2a** defined by a radius **220** (FIG. 5B) centered at an origin **O1**. The surface **H2a** preferably describes a maximum of 180 degrees between first and second ends **222a,222b**. The radius **220** is equal to or minimally larger than a radius of the outer cylindrical surface of the pin assembly **PA2**. The surface **H2a** defines á point **224** that lies halfway between the ends **222a,222b**.

A first plane **N1** can thus be defined as passing through the point **224** and the origin **O1**. A second plane **N2** can be defined as passing through the origin **O1** and the axis **X1**. In the illustrated embodiment, a hook angle **α** is defined between these two planes **N1,N2** and is less than 90 degrees. The hook **H2** is preferably conformed so that its mouth **142** opens in a direction oriented toward the first end **E1** of the frame **12f** so that an associated pin **P2** moving into the hook **H2** from the mouth **142** toward the inner surface **H2a** upon movement of the link **12** relative to the pin assembly **PA2** must move with an axial component of movement away from the first end **E1** and toward the second end **E2** of the frame **12f**. This arrangement facilitates engagement of the hooks **H1,H2** with the pin assemblies **PA1,PA2** by simply manipulating the arm **10** and link **12** (as described below) without manual operations to eliminate the need for an operator to exit his/her cab during this procedure.

With brief reference again to FIGS. 2A and 2B, the nose **28** of arm **10** includes or defines a temporary hook engagement region **68** with which the hook **H2** of link (specifically the tip **130** thereof) is selectively engageable as shown in FIGS. 1A and 1B. The region **68** is preferably defined by one or more

upstanding hooks or tabs **69**. When the hook **H2** of link **12** is engaged with the temporary hook engagement region **68**, the link **12** is unable to swing uncontrollably as could otherwise occur during coupling/decoupling operations. The hook **H2** of link **12** is preferably engaged with the temporary hook engagement region **68** for transport and storage of the arm assembly **A** to prevent swinging movement of the link **12**.

The attachment control link **12** comprises an unobstructed pin guide surface or ramp **90** (see FIG. 5B) that curves or slopes from the inner surface **S2** of the link **12** into the mouth **142** of the hook **H2**. This pin guide surface **90** is unobstructed in the sense that no other portion of the link **12** projects outwardly from this surface in a manner that would block or inhibit sliding or other movement of the pin assembly **PA2** on or adjacent the ramp **90** as the pin assembly **PA2** is received by the mouth **142** of hook **H2**.

Operation of the arm assembly **A** to couple an associated attachment **B** thereto is now disclosed (the decoupling procedure is the reverse of the coupling procedure) with reference to FIGS. 7A-7C (the arm assembly A is shown only diagrammatically in FIGS. 7A-7C for ease in understanding the coupling/decoupling sequence). To pick-up an attachment **AT**, the link **12** is retracted, preferably fully so that the hook **H2** engages and is retained in the hook engagement region **68** of arm **10** (unless the hook **H2** is already engaged with the hook engagement region **68**). With the first pin retainer **40** in its first operative (unlocked) state, the arm **10** is moved so that the first pin assembly **PA1** of the attachment **AT** is fully received into the hook **H1** (it may be necessary for the operator to drag the attachment **AT** on the ground slightly to move the pin assembly **PA1** into the hook **H1**). The pin capturing system **C1** is then operated to move the first pin retainer **40** to its second operative (locked) state so that the first pin assembly **PA1** is captured in the first hook **H1**.

After the operator is certain that the ground crew is clear of the area near the attachment **AT**, the attachment **AT** is then lifted so that it hangs freely slightly

off of the ground as shown in FIG. 7A. With reference to FIG. 7B, the arm **10** pivoted relative to a vertical plane **V** as indicated by the arrow **A1** (i.e., the arm **10** is pivoted inwardly toward the machine to which it is connected) so that the second pin assembly **PA2** goes through the vertical plane **V** moving inwardly toward the machine. The rod **18** of the cylinder **14** is then extended, so that the second hook **H2** is located as shown at least partially vertically below the level of a horizontal plane passing through the center of the second pin assembly **PA2** and also outward of the pin assembly **PA2**.

As shown in FIG. 7C, the arm **10** is then pivoted outwardly away from the machine in an opposite direction **A2** through the vertical plane **V**, so that the pin assemblies **PA1,PA2** pass through the vertical plane **V** and so that the hook **H2** moves toward the pin assembly **PA2.** Those of ordinary skill in the art will recognize that the rod **18** is extended and/or retracted during this operation as necessary to control the position of the link **12**, and the arm **10** is pivoted relative to the plane **V** to vary the angular position of the attachment **AT** relative to the arm **10** until the second pin assembly **PA2** is located in contact with or at least adjacent the ramp **90** of the link **12** and, ultimately, is received fully in the hook **H2** by sliding movement along the ramp **90** into the hook **H2**, i.e., the ramp **90** guides the pin assembly **PA2** into the hook **H2**. In the case where access to the second pin assembly **PA2** is somewhat limited by the presence of a box-type frame or the like, it is possible to vary the angular position of the attachment **B** as described in combination with movement of the link **12** so that the hook **H2** is able to receive the pin assembly **PA2** as required. Thereafter, the pin capturing system **C2** is actuated to move the second pin capture member **140** from its first (unlocked) position to its second (locked) position to capture the second pin assembly **PA2** in the hook **H2** as shown in FIG. 7C. At this point, the operator or an assistant can insert the stop-pins **SP** into the second pin-receiving locations **60b,160b** of the arm **10** and link **12**, respectively, as shown in FIGS. 7D,7E if desired. It should be apparent from the foregoing that an arm assembly **A**

formed in accordance with the present invention and operated according to the described coupling/decoupling method is advantageous owing to the fact that an operator can couple to or decouple from an associated attachment **AT** without assistance from a ground crew and without leaving the operator's cab of the excavator or other machine to which the arm assembly **A** is operatively connected. No mechanism is required to spread the hooks **H1,H2** apart from each other to engage pin assemblies **PA1,PA2**, and the arm assembly **A** is not limited to use with pin assemblies **PA1,PA2** that are spaced a set distance apart from each other, i.e., the arm assembly **A** is usable with different pin-to-pin spacings for pin assemblies **PA1,PA2**. As noted, decoupling of an associated attachment **AT** is preferably performed by reversing the above-described coupling method.

FIGURE 7D shows an associated attachment **AT** operably coupled to the arm assembly **A** with the attachment in a first operative position often referred to as a roll-back or dump position. FIGURE 7E is identical to FIG. 7D but shows the rod **18** of control cylinder **14** fully extended to move the attachment **AT** into a second operative position often referred to as a curled position.

FIGURES 8 and 9 illustrate a sleeve member **PS** that is preferably used in connection with an arm assembly **A** formed in accordance with the present invention to account for different attachment pin lengths and diameters and also to improve overall performance. The sleeve **PS** comprises a cylindrical tubular member **300** defining a through-bore **302**. First and second spacers **304a,304b** are connected by welding or other means to or formed as a part of opposite first and second ends of the tubular member **300**. As illustrated, the spacers **304a,304b** define inner guide surfaces **306a,306b** and outer bearing surfaces **308a,308b**, respectively. The guide surfaces **306a,306b** are beveled or otherwise are conformed to taper in a direction moving inwardly away from the bearing surface **308a,308b**. The bearing surfaces **308a,308b** are preferably planar. The spacers **304a,304b** define respective grooves **310a,310b** in which

first and second O-ring seals **312a,312b** are received so that the O-ring seals extend axially outward beyond bearing surfaces **308a,308b**, respectively. Each spacer **304a,304b** includes or defines at least one lubrication channel **314** that extends between the respective outer surface **316a,316b** and the bore **302**, axially inward of (between) the O-ring seals **312a,312b**. Conventional grease fittings **320** are installed in the lubrication channels **314**.

As noted, the attachment **AT** (FIG. 1C) comprises first and second pin assemblies **PA1,PA2** each comprising a sleeve **PS**. As shown in FIG. 9, the pin assembly **PA2** comprises a sleeve **PS** coaxially secured about a conventional attachment pin **P2**. The conventional pin **P2** is connected to and extends between first and second parallel spaced-apart ribs **R1,R2** of the attachment **AT**. The sleeve **PS** is coaxially arranged with the pin **P2** so that the pin **P2** extends through the bore **302**. The pin **P2** is non-rotatably secured to the ribs **R1,R2** by pin holders **PH2a,PH2b**. The sleeve **PS** is conformed and dimensioned so that it fits closely between ribs **R1,R2** with the seals **312a,312b** sealingly engaged with the ribs **R1,R2**, respectively, for a particular attachment or class of attachments. Also, the bore **302** is conformed and dimensioned so that the conventional attachment pin **P2** is closely slidably received therein with minimal space between these two components. With the sleeve **PS** operatively positioned, the bearing surfaces **308a,308b** lie adjacent and slidably contact ribs **R1,R2**. Although not shown in detail, the pin assembly **PA1** includes a sleeve **PS** connected to a conventional attachment pin **P1** and is otherwise structured in the same manner as the pin assembly **PA2**.

When installed as shown in FIGURE 9, the sleeve **PS** is freely rotatable relative to the conventional pin **P2**. Lubrication such as grease can be introduced into the through-bore **302** via fittings **320** and channels **314**. The O-rings **312a,312b** confine the grease to the bore **302** and to the area between bearing surfaces **308a,308b** and ribs **R1,R2**, while preventing or at least inhibiting entry of dirt, water and other contaminants into these same areas.

The tubular portions **300** of the sleeves **PS** are received into and captured in hooks **H1,H2**. This arrangement allows for the hooks **H1,H2** to have fixed widths while different lengths of sleeves **PS** corresponding to different spacings between attachment ribs **R1,R2** of various classes of OEM attachments **AT** are used together with conventional attachment pins **P1,P2** to adapt a conventional attachment **AT** for being coupled to the arm assembly **A.** The sleeves **PS** of pin assemblies **PA1,PA2** are non-rotatably held in the hooks **H1,H2** of arm assembly **A** so that no lubrication is required at this interface and so that sleeves **PS** rotate about the conventional pins **P1,P2** where sufficient lubrication and cleanliness are ensured. The bearing surfaces **308a,308b** engage the ribs **R1,R2**, respectively, and rotate relative thereto with minimal wear owing to the large surface area, lubrication and relative cleanliness owing to seals **312a,312b**. The sleeves **PS** are easily replaced when worn.

It should also be noted that the use of the sleeves **PS** as described reduces the cost and assembly time for the link **12** and arm **10** in that the non-rotatable interfaces between the link **12** and the sleeve **PS** and arm **10** and sleeve **PS** do not require expensive and time consuming machining operations as would be required for a rotatable interface. Also, there is minimal wear at the interface between hooks **H1,H2** and pin assemblies **PA1,PA2** owing to the lack of rotation between these components.

FIGURES 10A and 10B illustrate an alternative link **12'** that can be used as an alternative to the link **12** in the arm assembly **A**. Except as shown and/or described, the link **12'** is identical to the link **12** and like reference numerals including a primed (') designation are used to identify like components relative to the link **12**. Unlike the link **12**, the link **12'** the tip **130'** is shortened and made from thicker and stronger steel. The tip **130'** does not include a slot that receives the tip **148'** of second pin retainer **140'**. As such, under certain conditions, the tip **130'** has been found to have increased resistance to deformation relative to the tip **130** including the slot **132**. When the second pin retainer **140'** is extended to

its second operative position as shown in FIG. 10B, the tip **148'** thereof abuts tip **130'** but is not otherwise engaged therewith.

The invention has been described with reference to preferred embodiments. Alterations and modifications will occur to those of ordinary skill in the art upon reading this specification, and it is intended that the claims be construed as encompassing all such modifications and alterations.